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ABSTRACT

Windowless school buildings are currently being proposed as a design solution to the problems of vandalism, energy conservation, and building costs. However, little consideration is being given to the effects of windowless classrooms on the students and teachers inside. This thesis describes the effect of windowless classrooms on three specific areas of cognitive behavior: rote learning, concept formation, and perceptual ability. In addition, a description of student and teacher affective behavior, based on formal observations, is included. Two identical sixth-grade classes were selected for the study. The experimental period was divided into two three-week phases. Each classroom had all existing windows covered during one phase. Students were randomly divided into three test groups for the testing phases of the study. No consistent trends emerged to allow definitive judgment that windowless classrooms are detrimental to student cognition and learning. The only definitive trend is in the realm of affective behavior, indicating that student aggression increases in windowless environment. (Author/MLF)

THE EFFECTS OF WINDOWLESS CLASSROOMS ON THE COGNITIVE AND AFFECTIVE BEHAVIOR OF ELEMENTARY SCHOOL STUDENTS

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THESIS

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ABSTRACT

Windowless school buildings are currently being proposed as a design solution to the problems of vandalism, energy conservation, and building costs. However, little consideration is being given to the effects of windowless classrooms on the students and teachers inside. The intent of this thesis was to describe the effect of windowless classrooms on three specific areas of cognitive behavior: rote learning, concept formation, and perceptual ability. In addition, a description of student and teacher affective behavior, based on formal observations, was included.

Two identical sixth grade classes were selected for this study. The experimental period was divided into two three-week phases. Class A_1 began the experimental period with all existing windows covered. Class A_2 was left unmodified. Students and classes were allowed to function as usual during each experimental phase. Students in each class were randomly divided into three test groups for the testing phases of the study. Testing took place in the same classroom in which students were currently functioning. Group C_1 received a rote learning task and was asked to memorize a sequence of seven nonsense trigrams. Group C_2 received a concept formation test that involved combining the properties of size, shape, and color into a correct concept. Group C_3 was given the MacGregor Perceptual Index. During the second experimental phase the environmental conditions were reversed for the two classrooms. In addition, observations were taken in the areas of aggressive behavior, destructive behavior, and boredom.

Analysis of variance and a simple main effects analysis revealed the following significant ($p<.01$) results:

1. For the rote learning task, class A_1 performed better in a windowed environment while class A_2 performed better in a windowless

environment.

2. For the conceptual learning task, class A_1 performed better in a windowless environment while class A_2 performed better in a windowed environment.

3. No differences were noted in the perceptual tasks.

Thus, the classes responded to the windowless environment in the opposite manner from each other, and each task group within the class responded differently to the windowless environment. The analysis of the affective behavior indicated that aggression in both classes increased in a windowless environment, as did teacher frustration.

It was concluded that it was not possible to pass a definitive judgement that windowless classrooms are detrimental to student cognition and learning. Students were significantly affected by their environment, but no clear relationships could be drawn, probably due to the influence of unidentified variables. Suggestions for further research are offered.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Since the beginning of history, man's relationship with his environment has been an important key for his well-being. Whether it was for simple survival or for more philosophical reasons, man has always studied how he can or should relate to the environs about him. Recent concerns, such as overpopulation, ecological impacts of technology, and energy shortages have contributed a certain amount of urgency to the definition of what man's relationship with his environment should be. Architects, engineers, planners, environmental researchers, psychologists, sociologists, and others are now directing their attention to the investigation of this subject. Engineers are vigorously working on developing alternative energy sources. Environmentalists are pushing litigation for cleaner water and air and for control of man-made expansion into critical land areas. Psychologists are studying with more interest the impact of a technological environment on human behavior.

The architect and engineer are becoming more aware of problems dealing with the man-made environment which they must confront and solve. Research is the key to finding these answers, whether or not the architect or engineer does the needed research himself or relies on research done in other disciplines. It has been said that as technology increases, experience decreases. To the architect, this means a re-thinking of basic life styles, usages of space, responses to environment, construction methodology, economics, mechanical systems, building materials, and the basic needs of man. As more information becomes available from other disciplines, the architect can become more aware of the effects of man-made environments upon natural environments and upon man himself. The architect must be sensitive to environmental impact studies, psycho-sociological studies,

and educational studies as he approaches his designs. This awareness, coupled with the architect's own ingenuity and perhaps through his own research, can enable the architect, engineer, or planner to be the creator of a better environment.

PURPOSE

It is the intent of this thesis to study one very specific topic, thereby adding to the research already contributed dealing with human behavior in a man-made environment. The effect of windowless environments on human behavior has been studied many times, but without conclusive results. It is, therefore, the purpose of this thesis to measure the effects of windowless classrooms on the cognitive and affective behavior ot elementary school students. Three cognitive areas will be studied: rote learning, concept formation, and perceptual ability. Four specific areas of affective behavior will be studied: aggression directed toward other students, aggression directed toward the teacher, boredom, and destructive behavior.

DEFINITIONS

The following definitions will be used throughout this paper.

1. Window - a direct visual connection with the surrounding outside natural environment, other than a door.

2. Door - a means of egress from an interior space to an exterior environment.

3. Windowless environment - an interior space lacking a window.

CHAPTER TWO

This chapter deals with modern research on man's capability to adapt to his environment and on windowless environments. Only the most relevant research is offered as a means of acquainting the reader with the current direction of research and state of knowledge in these fields. Other related research, while not directly cited in the text, is noted in the author's bibliography.

The information is grouped into two categories. The first category, background research not directly related to windowless rooms, is included as a general background to research on man's capacity to respond and adapt to an environment. The second category is composed of research directly related to windowless environments.

BACKGROUND RESEARCH

Human factors research, while never flawless, has suggested that man is sensitive to his environment and affected by it. It appears that man can adapt to his environment either to survive or to perform a task. E. C. Poulton, a human factors researcher, reports that people can become partly acclimatized to certain environments, such as a very hot or a very cold environment. They also can become sensitized by previous exposure to an environment. People who are unable to deal with an environment tend to keep away from it. Those who remain are, to a certain extent, self-selected. They should be able to perform rather more efficiently than the unselected new-comer. Poulton further suggests that certain types of people can adapt or perform more efficiently in one environment than others. In addition, he also reports that the well-learned task is less affected by environmental changes than an unlearned task.[1] In effect, then, an

environment may be a positive or negative influence upon the people in that environment, depending on the personal characteristics, the task, or the amount of time spent in that environment.

Industry is experiencing problems with employee dissatisfaction and it is the conclusion of Alan D. Swain, human factors researcher at Sandia Laboratories in Albuquerque, New Mexico, that direct efforts by management to reduce the dehumanizing aspects of industrial jobs do pay off. Dr. Swain comments, "These direct efforts include selective use of automation, avoiding overselection and overtraining of workers, worker participation, and horizontal and vertical job enrichment."[2] He also sees the reducing of dehumanization in industrial jobs by creating a more enriched and natural working environment. The use of more windows and getting away from the enclosed, windowless factory is one possible solution.[3]

Frederick Herzberg, in a book concerning managerial theory and work motivation, cites extensive research on motivation within business and proposes a theory concerning organizational factors of motivation. He theorizes that some job conditions, whether present or not, do not strongly motivate employees. These factors, dealing mainly with job context or environment, include company policy and administration, salary, interpersonal relations, supervision, and working conditions. These are called the maintenance factors since they provide satisfaction at a reasonable level. The main motivational factors appear to deal with job content or performance and include achievement, recognition, the work itself, and responsibility. The interesting finding in this study is that out of ten factors, the working conditions factor was rated as least important in the working environment. Working conditions least motivated

the employee and was listed as the second lowest dissatisfier.[4]

Testing the ability of humans to adapt to new environments is an endeavor of current interest. One of the main goals in the following study was to perfect a test capable of determining who can and who cannot adapt to a 48-hour wake-sleep cycle.

A French geologist, Michel Siffre, was the recent subject of extensive research designed to determine man's ability to endure long periods of total isolation. He spent six months alone in an experimentally-rigged underground cave to measure the psychological and physiologioal effects that confinement has on the subject. The results indicated that confinement, or isolation, or both, contributed to a grave deterioration of Siffre's mental and manual dexterity.[5] This cave was, in effect, a windowless environment, albeit combined with the factor of isolation. This condition has dramatic effects on an adult subject, but many questions can be engendered from this study, such as: the effects of isolation in a windowed environment, the effects on males and females, and the effects on the aged and on children. Perhaps also, some of the same detrimental effects could occur over long-range exposure to windowless environments.

It has been shown that many physiological functions of the body, such as hormonal secretions, urinary excretions, and digestion are influenced by the day-night cycle. E. Bünning, a research biologist, discusses these influences in his book, Die Physiologische Uhr.[6] Likewise, Jacob and Stück, both research biologists, write about the possibility of an actual breakdown of the health of a child as a result of continued interference with his biological rhythm.[7]

The human eye, on the average, develops from a state of farsightedness

at birth to a normal adult state, known as emmetropia, The most critical time for the development of the eye occurs from the age of eight until adulthood.[8] Paul W. Seagers, a school building consultant and professor of education, reports that eye fatigue can be reduced and aid to the development of the eyes in adolescent students can be provided by occasionally glancing about or looking out-of-doors during close work.[9] Thus, windowed rooms can provide a source of benefit in insuring the proper physiological development of the eye.

More recent studies, however, minimize the importance of light in physiological development and functioning. J. Aschoff, a research physiologist, concludes his study on circadian rhythms in continuous darkness with the comment that, "Social cues are sufficient to entrain human circadian rhythms and absence of light has no immediate effect on the functions measured."[10]

DIRECT RESEARCH

The studies previously mentioned dealt generally with the effects of sunlight deprivation, with the capacity of the human to respond and adapt to differing environments, and with human physiological development and functioning. Dealing more specifically with windowless environments, architects and physiologists alike have expressed concern about the effects of lack of sunlight on office workers located in huge windowless building complexes equipped with vast arrays of flourescent lights that produce rays primarily in the green-yellow spectrum. Tests have shown that exposure to these lights may adversely affect visual acuity and increase fatigue.[11] Because so many modern office complexes are designed to filter out ultraviolet light and because workers often come and go in the dark

or in subways or other public transportation, no natural ultraviolet penetration occurs, with possible detrimental effects on the workers. Likewise, Russian research has shown negative consequences in factory production as a result of continuous usage of artificial lighting.[12]

J. A. Chambers, a research psychologist, found in his study of attitudes and feelings about windowless classrooms that the majority of his subjects had favorable attitudes toward windowless classrooms.[13] Other studies indicate that windowless classrooms neither improved nor hindered the cognitive performance of students or teachers.[14]

A noteworthy study by the Architectural Research Laboratory of the University of Michigan describes the behavioral reactions of both students and teachers in two primary schools over a period of two and one-half years.[15] This extended field study represents one of the few well-done studies in this area. Subjects spent an entire school year in the existing fenestrated classrooms, then a full school year with all windows in the test school replaced with opaque panels, and then another half-year with the windows restored. The objective of this study was to determine whether or not the windowless conditions affected the students' learning achievements as compared with their previous work in the same classroom before it was altered. The results showed no positive improvement in students' learning achievements. Along these lines, R. Sommer reported that windowless environments induce greater absenteeism, as well as other 'escape' behaviors.[16] Other researchers noted differential responses to windowless environments according to the subject's physical position in the room and differential responses according to the sex of the subject.[17]

The Ontario Department of Education conducted a study of the effects

of light (window) deprivation in the blind. R. J. Stiriling, an architectural researcher, reported two unique results. First, even though blind students are unable to see the sun or view outside through a window, they can sense the warm sunlight, hear outside noises, hear acoustical differences between windowed and windowless classrooms, and feel the heat gain and loss through the windows. Secondly, blind students deprived of windowed rooms were negatively affected, as were their teachers.[18]

Jerómi Tognoli, in studying the effects of windowless rooms on attitudes and retention, used three environmental variables--type of chair, presence or absence of windows, and the embellishment of the experimentally controlled environment--to measure the subject's attitude and performance on a retention task. The results are complex and no definitive conclusion is reached. He does recommend, however, that individuals in various environmental settings need to be studied on a multivariate level and in a more total everyday situation, maintaining that studies performed just in experimental settings are lacking in knowledge of the total make-up of the subjects used.[19]

Obviously, human factors research is complex and demanding, which may account for the glaring lack of well-designed studies in the area of effects of windowless classrooms. Even a computer search for related articles and studies, performed by the Technology Application Center in Albuquerque, New Mexico, derived less than fourteen pertinent references. Most of the studies referenced are limited in their generalizations and the parameters of each design must be taken into account in interpreting their findings.

Belinda L. Collins, in Windows and People: A Literature Survey,

also concludes:

> Although the conclusion that windowless rooms are not particularly desirable appears legitimate, this opinion is not based upon a large number of investigations.... Much, though not all, of the evidence from the windowless classroom studies is inconclusive or inadequate.... Further investigation is needed to determine if dislike of a windowless space is in fact determined by the kind of task, the amount of personal interaction, the size of the space, and the variety of activity.[20]

Basically, the studies mentioned in this chapter suggest that: 1.) although the evidence is somewhat contradictory, the absence of sunlight seems to cause adverse physical reactions, 2.) man is somewhat capable of adapting to a new environment and that certain people may respond favorably to specific environments, 3.) performance on specific tasks may be affected by the environment, 4.) working conditions are not consciously recognized as strong motivational factors, and 5.) windowless classrooms may or may not have adverse effects on the ability of students to learn.

This sparse and contradictory research, plus the recognition that learning is not one single entity, prompted the author to the present study of the effects of windowless classrooms on three different aspects of learning: rote learning, concept formation, and perceptual ability. In addition, the effects of windowless classrooms on affective behavior were of concern. Further, when queried as to why windowless classrooms were presently being selected as the best design solution for new schools being erected, officials of public school systems replied that, among other economic reasons, the major intent was to reduce vandalism. Psychological and physiological criterion for the decision were non-existent, making the need for this type of study even more compelling.

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FOOTNOTES

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CHAPTER THREE

This chapter is devoted entirely to the author's individual research. The intent of this study was to describe the effects of windowless classrooms on student performance in three specific areas of cognitive behavior: rote learning, concept formation, and perceptual ability. These three areas of cognitive behavior were chosen because, from the many types and levels of thought, rote learning, concept formation, and perceptual ability were considered to be most representative of the types of learning occurring in a classroom setting.[1] Rote learning is the ability to memorize and is considered one of the basic processes for all other cognitive behaviors, such as learning the alphabet or spelling or mathematical procedures.[2] Concept formation refers to any activity in which the learner must learn to classify two or more somewhat different events or objects into a single category.[3] This is best illustrated in the classroom setting by the classification of animals, grammar, colors, and shapes. Perceptual learning refers to various changes in perception that can be brought about by learning.[4] Examples of perceptual learning in a classroom setting include learning how to read maps, learning to recognize a particular musical tune played with different instrumentation, learning to sketch with perspective, or learning to understand perceptual judgement.

In addition, a description of student and teacher affective behavior was included for further data. Four specific areas of affective behavior were observed, these being most readily seen in classroom settings: boredom, destructive behavior, aggression directed toward other students, and aggression directed toward the teacher.

This study was designed to answer the question of whether or not a windowless classroom affects the cognitive and affective behavior of

students. The analysis of the data was directed toward a conclusion bearing on the advisability of using windowless classrooms.

This chapter is broken down into the following sub-headings: Definitions, Methodology, Measurements, Results, Discussion, and Conclusion. In addition, each sub-heading is further broken down into sub-sections.

DEFINITIONS

The following definitions are used in this chapter.

1. Cognitive behavior - behavior resulting from an awareness and judgement.

2. Learning - a relatively permanent process that is inferred from performance changes due to practice.

3. Rote learning - the ability to memorize a given task, usually done without much understanding or done mechanically.

4. Concept learning - the ability to form a category by deducing the general properties of that particular category.

5. Perceptual thought - the ability to form an impression of an object by use of the visual senses.

6. Affective behavior - behavior resulting from feelings or emotions.

7. Aggression - an overt, offensive action or comment directed toward another person or object.

8. Boredom - a manifest behavior, such as yawning or doodling, resulting from tedium, enhui, or disinterest.

9. Destructive behavior - a manifest behavior directed toward the destruction or vandalizing of an object.

10. Frustration - a manifest behavior displaying some degree of anger or dissatisfaction.

11. Interaction with students - actions or behavior by the teacher eliciting mutual or reciprocal action.

12. Classroom structure - the format for scheduling interaction with students and teacher, classroom activities, and work assignments.

13. Split-plot research design - a research design used in experiments having two or more treatments allowing subjects to be blocked together in groups in order to partially isolate the effect of subject heterogeneity in testing treatment effects.

14. Tukey post-hoc comparisons - a statistical procedure allowing the researcher to explore the data after it is collected to find the source of significant effects without specifying in advance which specific effect will be studied.

15. Transformations - systematic alterations in a set of raw scores whereby certain characteristics of the set are changed while other characteristics remain unchanged.

16. Analysis of variance - a statistical method used to test statistical hypotheses about the significance of the differences (variance) between means for each group of test scores.

17. Significant difference - a statistical difference between group means that is probably not due to chance alone, but rather to the effects of the experimental treatment. Differences between means are usually accepted as significant if they fall at either the .05 or .01 probability level, indicating that these particular experimental results could happen by chance alone either five times, or one time, out of one hundred repetitions, depending on the probability level chosen.

18. Interaction - indicates that the effect of one independent variable is different at differing values of the other. For instance, the effect of

windowless classrooms on memorizing ability may be greater with differing amounts of classroom structure. It is conceivable, for instance, that windowless environments may be more detrimental to rote learning in a highly structured classroom situation than in a loosely structured classroom.

19. Simple main effects analysis - occurs if, after an examination and statistical analysis of the data, interaction between two independent variables is suspected. Additional insight concerning the results of the experiment may be gained by computing tests of simple main effects to determine exactly where the interactions lie.

The following terms refer to complex statistical computations used in analysis of variance. A complete discussion of these terms may be found in Roger E. Kirk's textbook, Experimental Design: Procedures for the Behavioral Sciences.[5]

1. Sum of squares - a means for partitioning the total variance into its component parts.

2. Mean square - is obtained by dividing a sum of squares by its degrees of freedom.

3. Degrees of freedom - the number of independent observations for a source of variation minus the number of independent parameters estimated in computing the variation.

4. F ratio - provides a test of the hypothesis that all treatment population means are equal.

5. Probability of F being exceeded - determined from a standardized table of F.

METHODOLOGY

INTRODUCTION

An elementary school situation was deliberately chosen for this study because, of all the facilities used in the formal educational process, the elementary school is the most likely to hold students in one room throughout the day. This is in contrast to junior high and high school schedules which require the students to change classrooms periodically during the day. Sixth grade students were selected as subjects because they were considered to best be oriented to a school environment and the most capable of performing the cognitive tasks.

A school having existing windows and two sixth grade classrooms with nearly identical room conditions were needed. Existing windows which could later be blocked were needed, thus allowing the same room to serve for both the windowed and windowless treatments. To eliminate any extraneous variables and to allow comparisons, it was necessary that both classrooms be identical in size, orientation, and shape. In addition, to further eliminate extraneous variables, it was necessary to have the two student populations be as nearly alike as possible in social background, age, numbers of males and females, and overall performance ability, with no special education students. Two classrooms were necessary to counterbalance the order in which the subjects experienced the environmental conditions. This counterbalance was necessary to randomize experimental error and to counteract the effects of order of presentation of treatments. This was accomplished by having the classes begin the experiment with opposite environmental conditions. One classroom received the windowed treatment first while the other classroom received the windowless treatment

first.

It was decided to begin the study on the first day after Christmas break. Because the students had been away from school for nearly three weeks, any previous acclimation the students and teachers had acquired for the classrooms would be minimized.

Non-participant observers, unaware of the purpose of this study, were used for the random observations of affective behavior. Not knowing the purpose of the study allowed the observers to give non-biased observations. It was assumed that because the students did not know the intent of the study or that they were being individually observed, the presence of the observer for brief intervals would be a minimal distraction. Because the teachers knew that the observer was focusing on the students, the teachers' behavior was assumed to be relatively unmodified by the observer's presence. Occasionally, however, observations were made of the teacher as well.

SUBJECTS

Subjects were 52 students eleven and twelve years old, enrolled in two sixth grade classes at Sandia Base Elementary School in Albuquerque, New Mexico. There were 29 subjects in one class and 23 in the other, with approximately equal numbers of boys and girls in each class. The majority of students were from middle and upper-middle class families housed at Kirtland Air Force Base East and in the Four Hills area of Albuquerque. Since the subjects were randomly enrolled in the two classes, IQ was presumed to be randomized as well.

PROCEDURE

The experimental period was divided into two three-week phases.

Class A_2 began the experimental period in the windowless environment (B_2) while Class A_1 remained unaltered (B_1). Students and classes were allowed to function as usual during each three-week experimental phase. During the second experimental phase the conditions were reversed for the two classrooms. Students were unaware of the purpose of the study. Students were tested at the end of each experimental phase. Testing was conducted in the classroom in which each student had been functioning. Subjects were randomly assigned to one of three test groups for each class. Tasks were specifically designed to measure performance in each of the three areas of cognitive processes. The rote and cognitive learning tasks were administered individually. The perceptual task was administered to the entire task group at one time. In addition, random observations of student and teacher affective behavior were made throughout the entire experimental periods by non-participant observers using a behavior checklist. Figure 1 illustrates the study design in sequential order.

CLASS A_1	CLASS A_2
WINDOWED B_1	WINDOWLESS B_2
THREE WEEK EXPERIMENTAL PERIOD	THREE WEEK EXPERIMENTAL PERIOD
TESTING PHASE 1	
WINDOWLESS B_2	WINDOWED B_1
THREE WEEK EXPERIMENTAL PERIOD	THREE WEEK EXPERIMENTAL PERIOD
TESTING PHASE 2	

FIGURE 1.
Sequential Order of Study Design.

RESEARCH DESIGN

A split-plot research design with Tukey post-hoc comparisons was used for gathering and analyzing the cognitive data. For a complete discussion of this research design, see Roger E. Kirk's textbook, Experimental Design: Procedures for the Behavioral Sciences.[6] Subjects were randomly selected to be in one of three test groups within each class and remained in that test group for each of the two test phases. In other words, the same subject took the same type of test in each testing phase. Figure 2 illustrates the split-plot research design.

		WINDOW B_1	WINDOWLESS B_2
CLASS A_1	ROTE C_1	SUBJECTS 1-8	SUBJECTS 1-8
	CONCEPTUAL C_2	SUBJECTS 9-15	SUBJECTS 9-15
	PERCEPTUAL C_3	SUBJECTS 16-23	SUBJECTS 16-23
CLASS A_2	ROTE C_1	SUBJECTS 24-33	SUBJECTS 24-33
	CONCEPTUAL C_2	SUBJECTS 34-42	SUBJECTS 34-42
	PERCEPTUAL C_3	SUBJECTS 43-52	SUBJECTS 43-52

FIGURE 2.
Split-plot Research Design.

DESCRIPTION OF THE EXPERIMENTAL ENVIRONMENT

Each classroom was identical in size, orientation, shape, color of paint and furnishings, and mechanical and electrical systems. The room size was appriximately 30' by 30' by 10'. The floor finish was green vinyl-asbestos tile in one room and brown vinyl-asbestos tile in the other. The walls were painted concrete block, painted to match the floor color. The ceiling was an acoustical lay-in tile, laid in parallel grids, off-white in color. The north wall in each room had identical windows 2'8" above the finished floor. One window was 7' by 8'. The other window was 7' by 4'. The south wall had a continuous row of 3' windows located 7' above the finished floor. The rooms each had 3' by 7' doors, one on the north wall, one on the south wall. The view out of the north windows was the same for each class, looking out onto an asphalted basketball court with a view of the mountains and houses in the background. The classrooms were located back-to-back and the access to both was an open-air covered walk on the south side. Both classes had south doors opening onto this walk and an open dirt playground.

The lighting fixtures were three rows of two-tube, ceiling hung flourescent fixtures, using cool white tubes. No forced air heating or cooling was used. A hot-water convection-flow wall base unit was located on the same common wall for both classrooms. Because ventilation in the rooms was poor, the doors were occasionally opened no more than one foot for short periods of time. The windowless condition was created by completely covering the windows with brown, single-faced corrugated cardboard sheets with the qorrugations facing inward.

MEASUREMENTS

COGNITIVE MEASURES

Rote learning: Rote learning was operationally defined as performance on memorization of a sequence of seven nonsense trigrams. A trigram is a three-letter syllable. Following a standard psychological serial learning procedure, subjects were asked to look at a series of seven 5" by 8" index cards, each card having a different nonsense trigram. After being shown all seven cards, subjects were asked to repeat the trigrams in order, by memory. The experimenter asked the subject what the first trigram was. Upon his response, the first card was shown. The subject was then asked what the next trigram would be and the process was repeated until all seven trigrams were correctly given to a criterion of three times in a row. A three-second time limit was allowed for each response before the succeeding card was shown. A different set of trigrams was used in each testing phase. A subject's score was the number of trials to criterion. A sample card used in the rote learning task is included in the Appendix.

Concept formation: Conceptual thought involved combining the properties of size, shape, and color into a correct concept. This task followed standard psychological concept learning procedures. The subject was told that the purpose of this task was to guess the thing (concept) that the experimenter was thinking of. He was told that he would be shown a series of 5" by 8" index cards with something (one concept) drawn on each. The subject was to tell the experimenter whether the picture was a winner or a loser, a winner being the correct concept. A series of thirty cards was shown. With each guess by the subject, the experimenter said "yes" or "no", depending on whether or not the guess was correct. When

the subject guessed the correct concept ten times in a row without error, he had completed the task. For example, the concept of small red triangle was randomly spaced within the cards. The concept was considered learned if the subject responded "winner" to each and every card with a small red triangle for ten consecutive times and "loser" to every other card. A subject's score was the number of trials to criterion. The correct concept randomly changed with each subject. A sample card used in the concept formation task is included in the Appendix.

Perceptual ability: Perceptual ability was defined as performance on the MacGregor Perceptual Index.[7] The Perceptual Index is a measure of perceptual efficiency geared to an elementary school population and consists of a booklet with 4½" by 3¼" black and white photographs, each posing a visual perceptual problem. Perceptual categories making up the Index are: perception of distance, embedded figures, shape, similarities and differences, the vertical, contour, and perception modified by constancy. The booklet was given to each subject and instructions for each section were given as each section was presented. For each of the 48 photographs, the subject's response was recorded on an answer sheet. The subject's score was the number of correct responses. A sample answer sheet for the Perceptual Index is included in the Appendix.

AFFECTIVE MEASURES

These measures were designed to determine the affective behavior of both the students and teachers throughout the entire course of the study. The data was collected by five non-participant observers who were naive to the purpose of the study. All observers were briefed so as to establish a uniform semantic interpretation of the observation scale and for the

uniform recording of subject behavior. Observing random subjects for random fifteen-minute periods from the back of the classroom, the observer would record each exhibited behavior in the proper place on the checklist. A separate checklist was maintained for each subject for each observation period. The student observation scale identified four major areas of behavior: aggression directed toward other students, aggression directed toward the teacher, boredom, and destructive behavior. The two teachers were also randomly observed and rated on a separate scale. This scale identified three areas of behavior: frustration, interaction with students, and classroom structure. Examples of the student and teacher observation forms used are included in the Appendix.

RESULTS

COGNITIVE DATA

A square root transformation was employed in this study to reduce the raw data to more manageable and uniform proportions. The transformed data is shown in Figures 3 through 8. It is evident from these figures that the performance of both classes on the rote and concept learning tasks varied with the environmental condition.

For rote learning, class A_1 showed a mean difference of .47 trials between the environmental conditions, performing better in a windowed environment. Class A_2 showed a mean difference of 1.33 trials between the environmental conditions, performing better in a windowless environment. It must be noted that, although all individuals in the class performed uniformly better or worse in the environmental condition, the classes as entire units responded exactly opposite to each other. For example, every

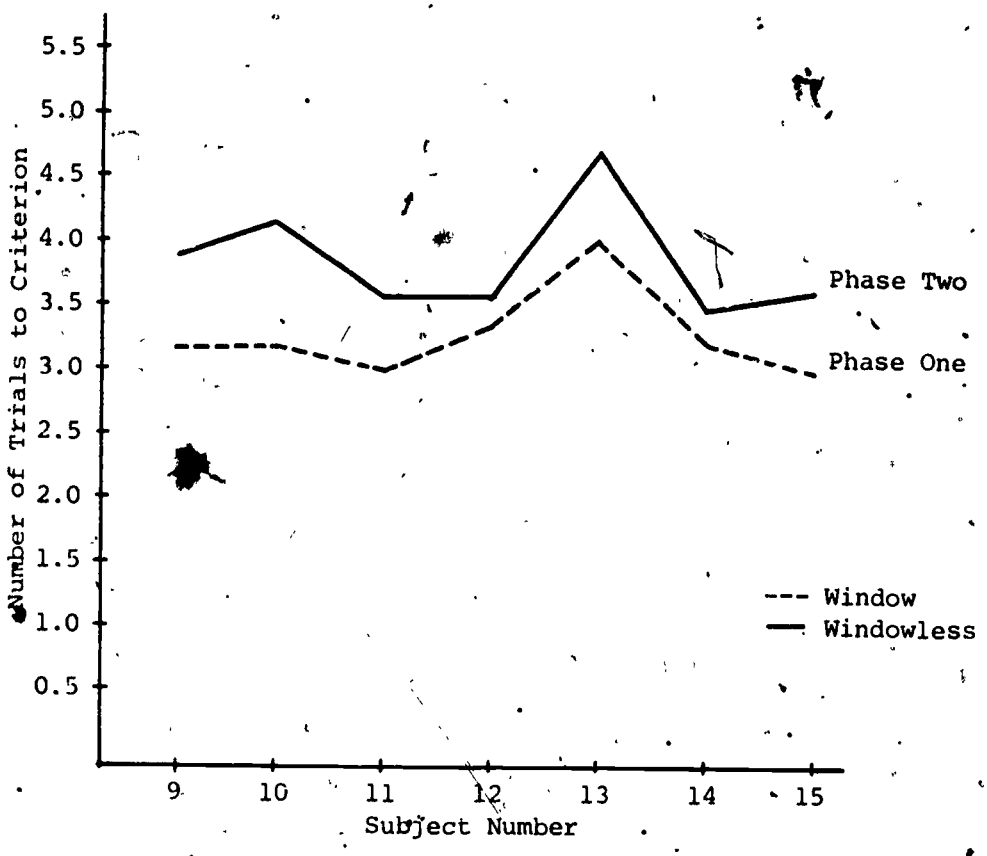


FIGURE 3.
Rote Learning Test Transformed Scores for Class A_1.

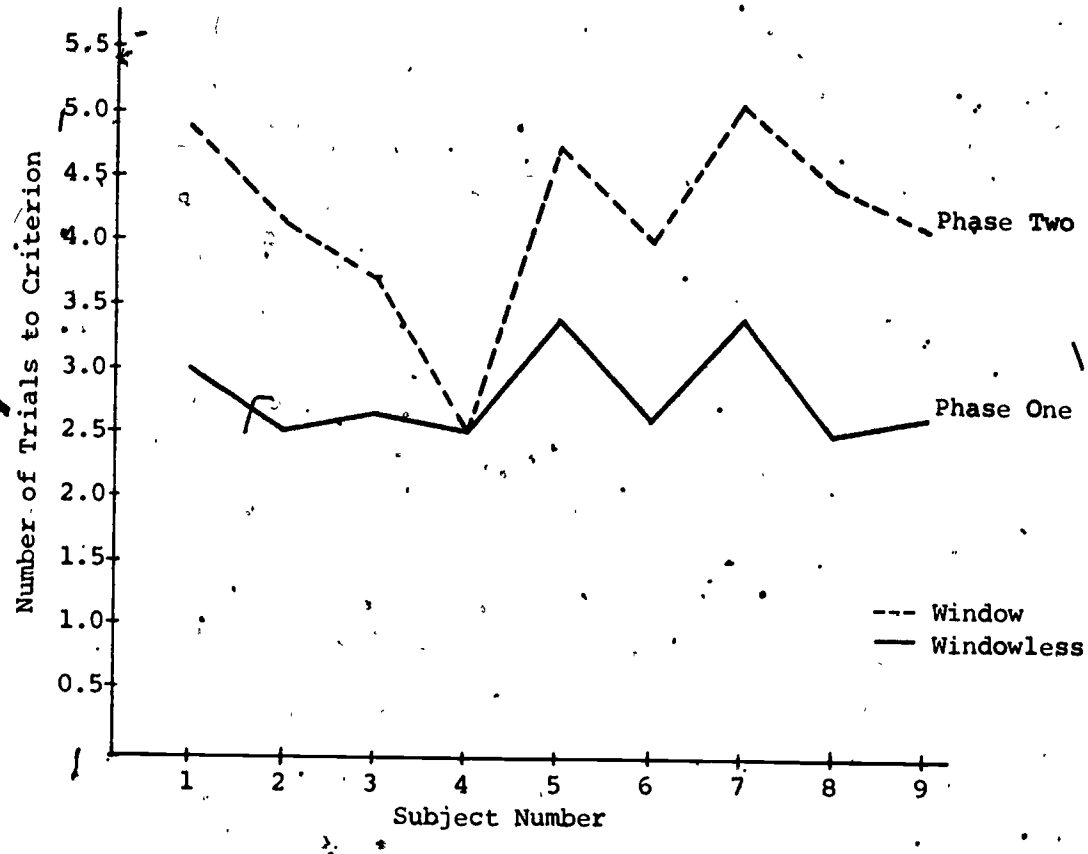


FIGURE 4.
Rote Learning Test Transformed Scores for Class A_2.

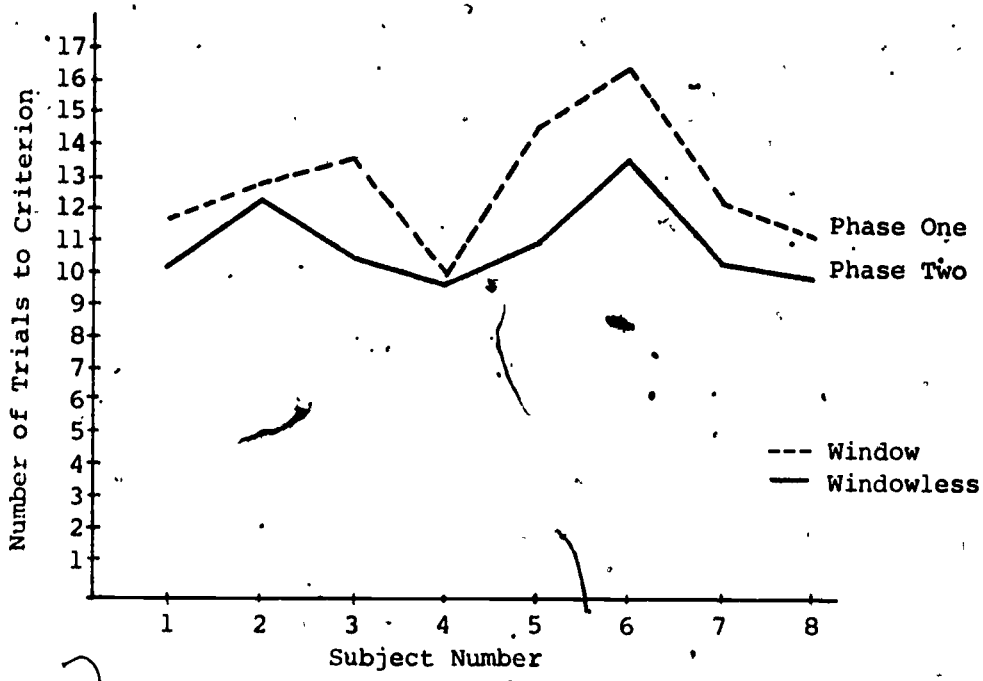


FIGURE 5.
Conceptual Test Transformed Scores for Class A_1.

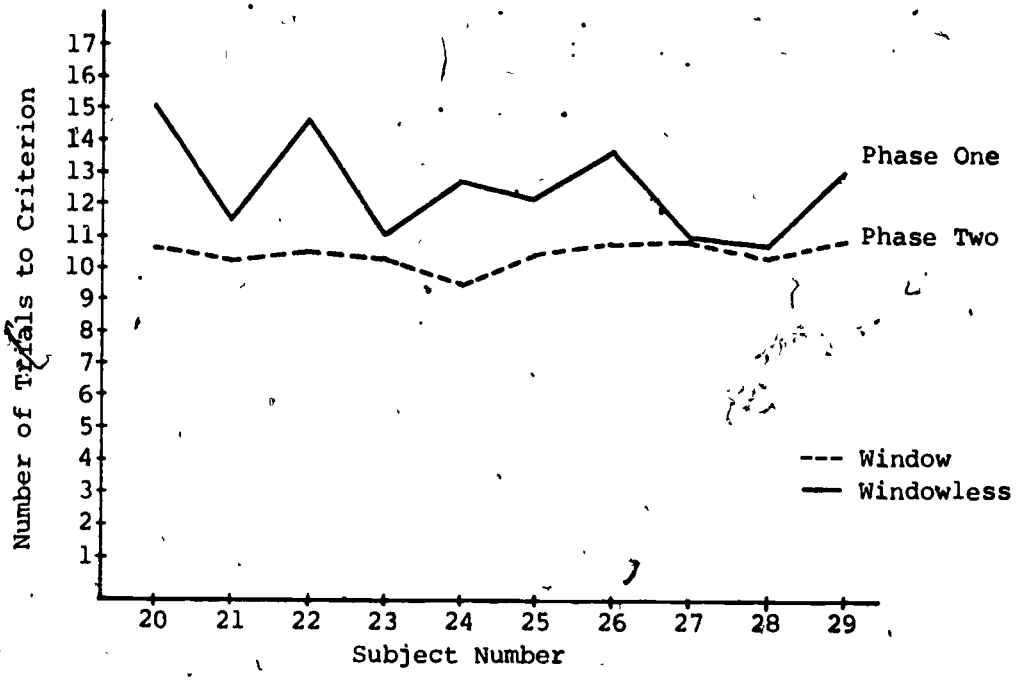


FIGURE 6.
Conceptual Test Transformed Scores for Class A_2.

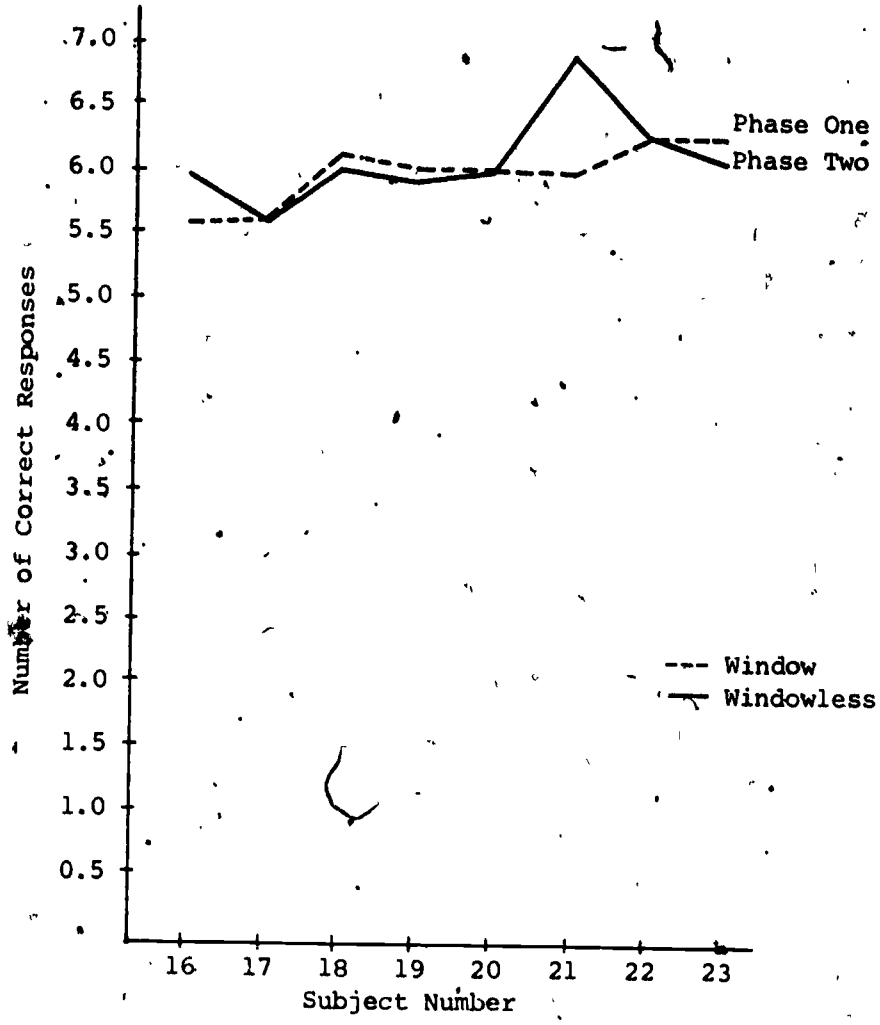


FIGURE 7.
Perceptual Test Transformed Scores for Class A_1.

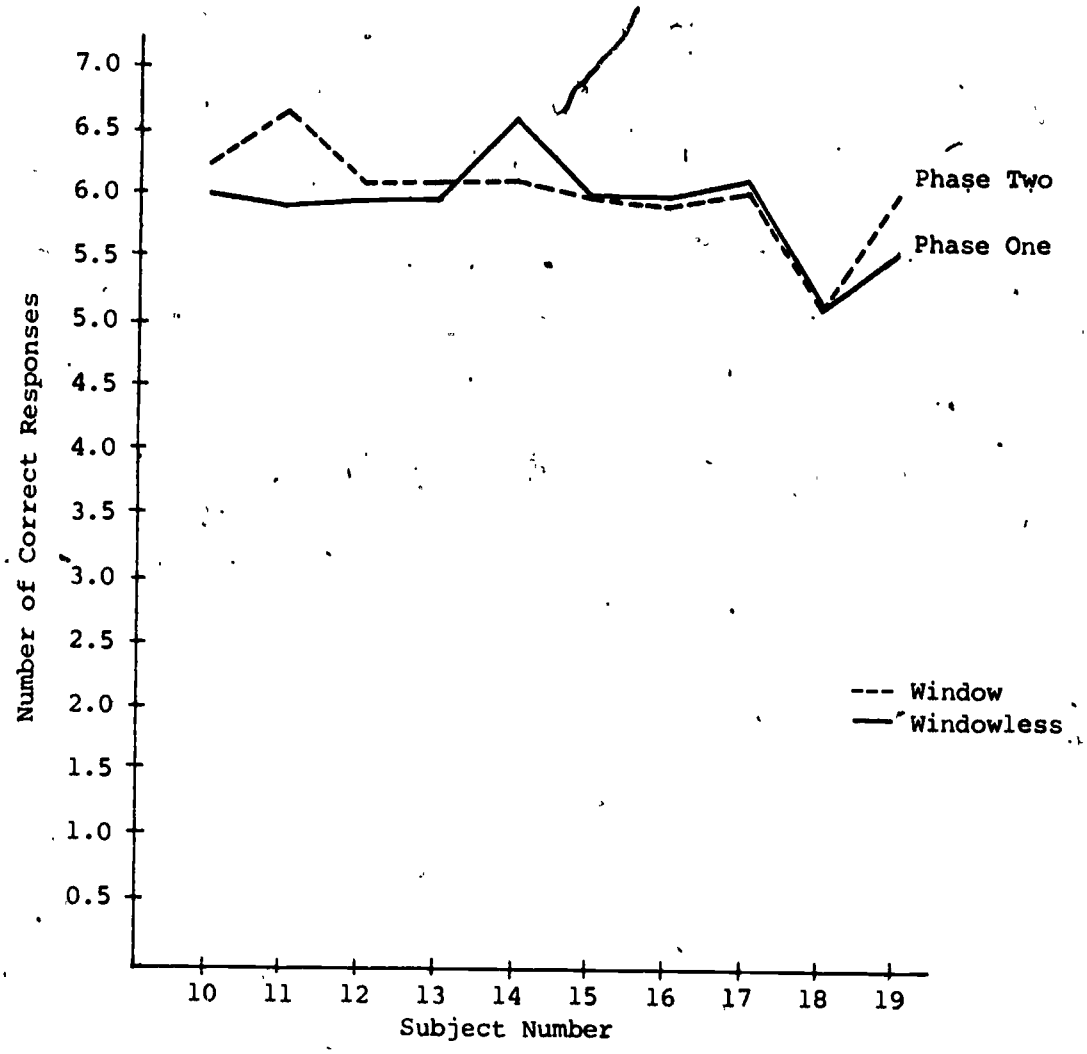


FIGURE 8.
Perceptual Test Transformed Scores for Class A_2.

student in class A_1 performed the rote learning task better in a windowed environment. Every student in class A_2, except for one student who performed exactly the same in both testing phases, performed the rote learning task better in a windowless environment, class A_2 responding to the same environmental conditions in the opposite fashion from class A_1.

These same results are also noted in performance on the conceptual learning task. The mean difference in performance under the two environmental conditions for class A_1 was 1.98 trials, class A_1 performing uniformly better in a windowless environment. The mean difference for class A_2 was 2.11 trials, class A_2 performing uniformly better in a windowed environment. The opposite within-class response is noted for the conceptual performance when compared with the rote performance of each class. For example, class A_1 performed the rote task better in a windowed environment, but performed the conceptual task better in a windowless environment. Thus, not only are there between-class variations, but the same class responds differently to the environment, depending on the task.

Performance on the perceptual learning task does not appear to be affected by the environment for either class. Class A_1 showed a mean variation of .12 correct responses while class A_2 showed a mean variation of .14 correct responses.

In order to determine whether or not the differences in performance noted above were significant and not due merely to chance, an analysis of variance was performed by adapting the BMDP 2V - Repeated Measures Analysis of Variance with Covariates computer program from the University of California at Los Angeles.[8] This data is contained in Table 1. It can be noted from this table that the probability of F being exceeded

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	PROB. F EXCEEDED
A - class	0.434	1	0.434	0.339	0.563
C - task	1178.726	2	589.363	460.885	0.000
AC	0.529	2	0.265	0.207	0.814
SUBJ. W. GRPS.	58.827	46	1.279	-	-
B - environ.	0.280	1	0.280	0.740	0.394
BA	2.653	1	2.653	7.010	0.011
BC	0.923	2	0.462	1.220	0.305
ABC	40.898	2	20.449	54.019	0.000
B x SUBJ. W. GRPS.	17.413	46	0.379	-	-
MEAN	5106.285	1	5106.285	3992.880	0.000

TABLE 1.
Analysis of Variance Source Table.

is less than .01 for C, or the task variable. This indicates that the mean score for all three tasks combined in testing phase 1 was significantly different from the mean score of all three tasks combined in testing phase 2. Likewise, a significant difference ($p<.01$) is noted at BxA, indicating that there was a significant response to the environment. Additionally, a significant interaction ($p<.01$) is noted at AxBxC, indicating an interaction between classes, environments, and tasks.

Since the information from the analysis of variance table is too general to be of much use, a simple main effects analysis was performed to determine more directly where the differences lie. The data from the simple main effects analysis is contained in Tables 2a, 2b, and 2c. These tables may better be understood with the following example. A significant source of variation ($p<.01$) is listed as B at AC_{22}, indicating that the performance of class A_2 on the concept learning task C_2 was significantly different under the two environmental conditions.

The most interesting results gleaned from Tables 2a, 2b, and 2c, are as follows:

1. Class A_1 performed the rote learning task significantly better in a windowed environment than in a windowless environment.

2. Class A_1 performed the concept learning task significantly better in a windowless environment.

3. Class A_2 performed the rote learning task better in a windowless environment, significantly better than in a windowed environment.

4. Class A_2 performed the concept learning task significantly better in a windowed classroom.

5. Class A_1 responded significantly opposite to the environment from class A_2.

SOURCE	SUM OF SQUARES	MEAN SQUARE	F	SIGNIFICANCE AT p<.05	SIGNIFICANCE AT p<.01
A at C_1	0.929		2.455		
A at C_2	0.048		0.127		
A at C_3	0.881		2.326		
ERROR		0.379			
C at A_1	547.273		1445.709	X	X
C at A_2	631.538		1668.309	X	X
ERROR		0.379			
A at B_1	3.671		4.429	X	
A at B_2	2.218		2.677		
ERROR		0.829			
B at A_1	2.545		6.723	X	
B at A_2	3.346		8.838	X	X
ERROR		0.379			
C at B_1	543.422		655.752	X	X
C at B_2	637.174		768.883	X	X
ERROR		0.829			
B at C_1	0.777		2.053		
B at C_2	1.955		5.165	X	
B at C_3	0.912		2.409		
ERROR		0.379			
A at BC_{11}	24.938		30.092	X	X
A at BC_{12}	3.000		3.620		
A at BC_{13}	0.085		0.102		

TABLE 2a.
Simple Main Effects Table.

SOURCE	SUM OF SQUARES	MEAN SQUARE	F	SIGNIFICANCE AT p<.05	SIGNIFICANCE AT p<.01
A at BC_{21}	13.179		15.903	X	X
A at BC_{22}	4.173		5.036	X	
A at BC_{23}	1.071		1.300		
ERROR		0.829			
B at AC_{11}	15.662		41.373	X	X
B at AC_{12}	1.160		3.064		
B at AC_{13}	0.060		0.159		
B at AC_{21}	22.303		58.916	X	X
B at AC_{22}	7.920		20.922	X	X
B at AC_{23}	1.128		2.980		
ERROR		0.379			
C at AB_{11}	368.614		444.810	X	X
C at AB_{12}	192.996		232.890	X	X
C at AB_{21}	199.160		240.328	X	X
C at AB_{22}	460.383		555.549	X	X
ERROR		0.829			
AB at C_1	37.187		98.236		
AB at C_2	7.125		18.822	X	X
AB at C_3	0.276		0.729		
ERROR		0.379			
AC at B_1	24.352		29.386	X	X
AC at B_2	16.206		19.556	X	X
ERROR		0.829			

TABLE 2b.
Simple Main Effects Table.

SOURCE	SUM OF SQUARES	MEAN SQUARE	F	SIGNIFICANCE AT p<.05	SIGNIFICANCE AT p<.01
BC at A_1	14.337		37.873	X	X
BC at A_2	28.005		73.980	X	X
ERROR		0.379			

TABLE 2c.
Simple Main Effects Table.

6. No significant differences were noted for either class in performance on the perceptual task under either environmental condition.

The analysis of the cognitive data also revealed that both classes did worse in their performance in the second rote learning test phase and improved their performance in the second conceptual learning test phase.

AFFECTIVE DATA

The analysis of the affective behavior observations is shown in Tables 3 and 4. The analysis of the affective behavior of students suggested that:

1. Class A_1 showed greater indications of boredom in a windowless environment.

2. Class A_1 showed more signs of aggressive behavior with other students in a windowless environment.

3. Class A_2 showed more signs of boredom in a windowed environment.

4. Class A_2 showed more signs of aggressive behavior with students and with the teacher in a windowless environment.

These results indicate that aggression increased in both classes in a windowless environment.

The analysis of the teachers' affective behavior data indicated only that:

1. The teacher of class A_1 showed greater signs of frustration in a windowless environment.

2. The teacher of class A_2 showed greater signs of frustration in a windowed environment.

These results indicate that the teachers had differential responses to the environment.

CATEGORY	CLASS A_1 NUMBER OF INCIDENTS		CLASS A_2 NUMBER OF INCIDENTS	
	WINDOW	WINDOWLESS	WINDOW	WINDOWLESS
AGGRESSION TO STUDENTS	0	5	1	10
AGGRESSION TO TEACHER	1	1	5	11
BOREDOM	62	81	112	47
DESTRUCTIVE BEHAVIOR	2	0	1	0

TABLE 3.
Student Observation Results.

CATEGORY	TEACHER OF CLASS A_1 NUMBER OF INCIDENTS		TEACHER OF CLASS A_2 NUMBER OF INCIDENTS	
	WINDOW	WINDOWLESS	WINDOW	WINDOWLESS
INTERACTION WITH STUDENTS	15	15	15	15
CLASSROOM STRUCTURE	0	1	0	3
FRUSTRATION	2	17	20	9

TABLE 4.
Teacher Observation Results.

DISCUSSION

Because the cognitive data revealed several significant interactions, a very complex interrelationship is indicated. Apparently, these three cognitive tests are not equally or uniformly affected by the environment, suggesting that the lack of windows does not produce consistent effects on student learning. Obviously, other unidentified factors also influenced the cognitive behavior of these students. It is interesting to note, however, that each task group in both classes performed uniformly better or worse in each of the test phases, suggesting that some factor of class composition may also exert an influence on class response to the environment. The fact that both classes did worse in the rote learning task in the second phase of testing, regardless of which environmental treatment the class was currently experiencing, might be due either to the fact that the syllables in the second phase may have been more difficult to memorize or that the learning of the syllables in the first testing phase interfered with the learning of the syllables in the second testing phase.

The affective observations suggest the one consistent trend. Aggression between students seemed to increase in a windowless environment. Perhaps the environment plays a more important role in our emotional and social well-being than in our learning process. Of interest, too, is the finding that teacher behavior coincided closely with student behavior. As student boredom increased so did teacher frustration, as might be expected.

One additional factor must be considered in discussing these test results. In most elementary schools there is much contact with the outside environment due to recesses, physical education classes, lunch hour, etc. In this study, students spent approximately 20% of their seven-hour

day (8:15 A. M. to 3:15 P. M.) in outside activities. In a case where so much outside contact is available, the need for windows may be minimized, suggesting that the need for windows varies proportionately with the amount of time one must spend in a windowless environment.

As a result of this study, a number of recommendations for future study can be suggested, including:

1. Further study might examine whether or not a subject responds to an environment in the same manner when studied individually as he does as part of a group. Does the group somehow provide enough distraction to minimize the effects of the environment?

2. The effect of teaching style, whether open or traditional, is open to examination and more study is needed to identify critical factors in classroom composition. What is it that makes a group a cohesive unit?

3. Other types of cognitive performance need to be studied, such as mathematical ability, artistic or musical creativity, creative ability, and likewise, physical performance.

4. This type of study needs to be repeated in a situation wherein no outside contact is permitted, perhaps in an office building.

5. What effects does the interior physical arrangement of rooms have? These questions and others have been raised and remain unanswered.

CONCLUSION

It was the intent of this thesis to examine the various psychological, physiological, religious, and artistic aspects of light and to determine if the elimination of natural light in an interior environment would in some way be detrimental to man. The basic conclusion drawn from this study is that no consistent trends emerge to allow one to pass definitive

judgement that windowless classrooms are detrimental to student cognition and learning. That students are influenced by their environment is evidenced in the significant effects that the environment has upon student performance, but no clear relationships can be drawn. The only definitive trend is in the realm of affective behavior, indicating that student aggression increases in windowless environments. Also an interesting result is that teacher frustration increases as student boredom increases. The results of this study do lend support to the premise that human performance is an aggregate of many different types and levels of cognitive and affective behavior units, presenting a complex interface and many unanswered questions. As Belinda L. Collins concludes, "There is no single solution, such as windowless buildings or minimal windows...because human requirements cannot yet be specified fully."[9] However, the response of so many people to the idea of a windowless room remains negative--"I couldn't stand being cooped up without windows," or "I'd go crazy without windows." The reason for such a strong emotional preference for windows is still unknown.

(The previous missing pages were deleted by the author)

FOOTNOTES

1. Rene Silleroy. Department of Psychology, University of New Mexico. Personal interview.

2. Henry Ellis. Fundamentals of Human Learning and Cognition. Dubuque, Iowa: William C. Brown Company, 1972, p. 109.

3. Ellis, op. cit., p. 137.

4. Ellis, op. cit., p. 156.

5. Roger E. Kirk. Experimental Design: Procedures for the Behavioral Sciences. Belmont, California: Brooks/Cole Publishing Company, 1968.

6. Kirk, op. cit., chapter 8.

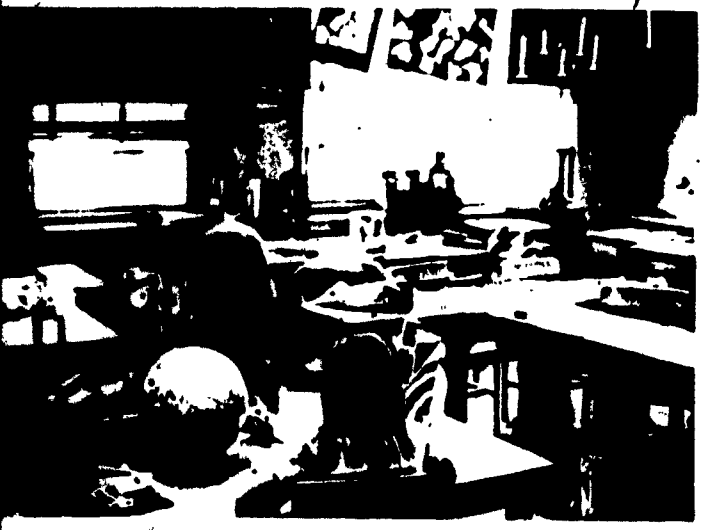
7. Ron MacGregor. Perceptual index. Studies in Art Education, 1974, 15(3).

8. BMDP 2V - Analysis of Variance and Covariance, Including Repeated Measures. Los Angeles, California: Health Science Computing Facility, June, 1974.

9. Belinda L. Collins, op. cit., p. 79.

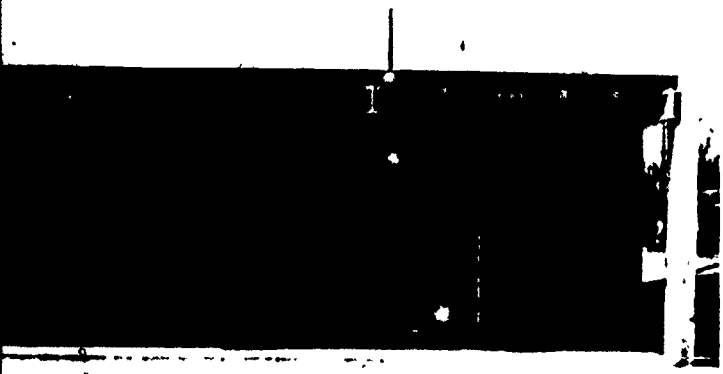
View of door in windowless condition - classroom A_1.

Windowless condition - classroom A_1.



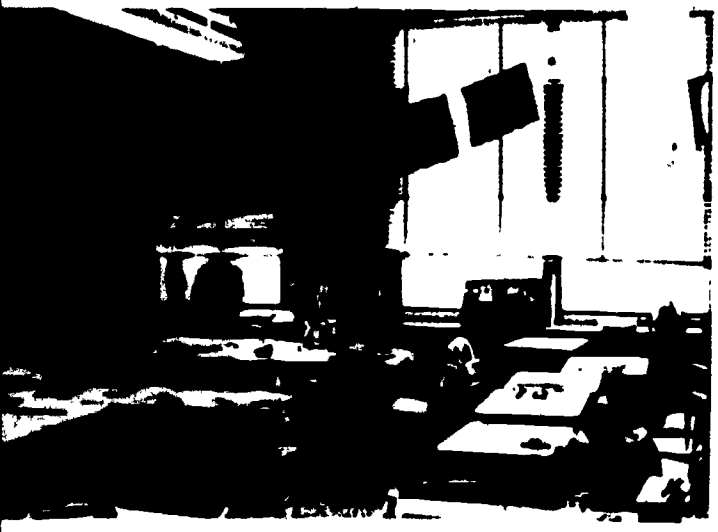
Testing in windowed condition

Testing in windowless condition



Southern view of classrooms.

Northern view of classrooms



Windowed condition - classroom A_1

Windowless condition - classroom A_1

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